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ABSTRACT

In 1991, the New Jersey Board of Higher Education's College Outcomes Evaluation Program (COEP) was canceled due to lack of state funding. Despite the cancellation, 17 community colleges formed the New Jersey County College Project on General Education to develop goals, objectives, and assessment criteria for general education. The Project grounds its efforts in the ideas of Lion F. Gardiner. Gardiner argues that in assessment planning, the first component of a successful course program should be the outcomes, or the student knowledge, skills, and achievements that are desired. Then, processes (i.e., courses, classroom techniques, and lab experiments) can be devised to achieve the goals, and inputs (i.e., human and nonhuman resources) can be acquired. Using this process for planning chemistry courses, the following two outcome objectives were developed and revised: (1) the student will exhibit an understanding of the scientific method: observe, make inference, classify and organize information, analyze and synthesize data, draw conclusions, and communicate those conclusions in writing; and (2) the student will be able to utilize information from the enormous and rapidly expanding chemical literature, both in libraries and in on-line interactive databases. The key to a positive and successful outcomes assessment program is a clear set of objectives and ownership and control by faculty and by local institutions. Contains 11 references. (TGI)

Sleeping with the Enemy: Making Outcomes Assessment Work in the Classroom

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SLEEPING WITH THE ENEMY:

MAKING OUTCOMES ASSESSMENT WORK IN THE CLASSROOM

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Abstract
The Outcomes Assessment movement is having a major impact on colleges across the nation. In New Jersey, the state-run Outcomes Assessment program was canceled a few years ago when its funding was eliminated. Remarkably, community college faculty and administrators are continuing the effort voluntarily, both at local campuses and on a statewide basis. What is motivating us to expend time and effort on a program that has been perceived as burdensome, judgmental, and "unacademic"? We are convinced that a clear, academically sound statement of measurable student goals and objectives can lead to dramatic improvements in course and program content and methodology. The author will describe the ongoing effects of this process on the AS Chemistry program, and on freshman and sophomore level (General and Organic) chemistry courses.

Outcomes Assessment, mandated by State Boards of Higher Education or their equivalents, by Governors, or by State Legislatures, is having a major impact on colleges across the nation. In New Jersey, the state-run Outcomes Assessment program was canceled a few years ago when its funding was eliminated. Remarkably, community college faculty and administrators are continuing the effort voluntarily, both at local campuses and on a statewide basis. What is motivating us to expend time and effort on a program that at times has been perceived as burdensome, judgmental, and unacademic? We are convinced that a clear, academically sound statement of measurable student goals and objectives can lead to dramatic improvements in course and program content and methodology. I will describe the ongoing effects of this process on freshman and sophomore level (General and Organic) chemistry courses.

Traditionally, content (already overwhelming and ever-growing), classroom methodology (predominantly lecture, with experiments designed to verify previously introduced theory), and assessment techniques (commonly objective examinations) have dominated chemistry teaching at the introductory level, as they have for most content-based courses. Whether we want or intend it, such factors have implicitly driven student outcomes and colored not only what we expect from our students, but also what they expect from the course. This result has contributed to the mutual sense of alienation in science education (Tobias, 1990) and has been criticized not only by experts in education and learning styles, but by the scientific establishment as well (American Chemical Society, 1989; American Association for the Advancement of Science, 1990; National Science Foundation, 1990).

Carefully thought-out goals and objectives, if developed and owned by the teacher, often necessitate profound changes in the content, teaching methods, and assessment techniques of the course. The content of introductory chemistry courses is a hotly debated topic, in the literature as well as at conferences and department meetings (Bodner, 1992; Spencer, 1992). It is a subject beyond the scope of this paper, but there is a consensus that a reduction in the quantity of material presented is an essential prerequisite to further reform. As far as teaching and assessment methods are concerned, the modem pedagogical toolbox is filled with methodologies which can be employed to foster and measure the desired outcomes: cooperative and collaborative techniques, critical thinking exercises, demonstrations and simulations, discovery or guided inquiry laboratories, information retrieval and analysis, and writing (papers, lab reports, and essay questions).

In this paper, I will draw on my experiences with Outcomes Assessment in New Jersey, as a participant at the State-wide level, as a member of a college task force, as a developer of program goals and objectives in the Science and Engineering Department, and finally as the teacher of two courses in particular: General Chemistry and Organic Chemistry. The focus will be on changes instituted by my colleagues and myself largely in response to goals and objectives that we had developed.

Outcomes Assessment in New Jersey

The New Jersey Board of Higher Education created the College Outcomes Evaluation Program (COEP) in June, 1985. Due to the economic do wnturn in the state, the program was canceled for lack of state funding in 1991. Although COEP was administered by the New Jersey Department of Higher Education and funded from the state budget, as determined by the Governor and the Legislature, from the outset, the program was designed and controlled largely by faculty and administrators from the colleges in the state. The higher education community in New Jersey is quite complex: large public (Rutgers, New Jersey Institute of Technology, University of Medicine and Dentistry) and private (Princeton, Fairleigh Dickinson) universities; baccalaureate and Masters level colleges, both public (the state college system, centrally administered by the Department of Higher Education) and private; and the county colleges, independent two-year associate degree granting institutions, controlled and funded by the counties, but deriving a significant amount of funding from the state. All sectors were included in COEP, both as mandated (and in some cases reluctant) participants and as contributors to its development and final form.

COEP had five principle components: (1) a General Intellectual Skills (GIS) test; (2) general education; (3) major subject programs; (4) student development; and (5) community impact. Of these, the GIS test was the most innovative and controversial. The COEP committee decided to develop its own instrument, intended to be administered to students at the beginning of the freshman year and again at the end of the sophomore year, in order to assess the effect of their college experiences on their intellectual performance (the value-added approach). The test was developed by the Educational Testing Service (ETS); at the insistence of COEP, and with the assistance of many college and university faculty members, ETS produced an exam that is quite unlike the familiar multiple choice exam for which it is famous. The student is given one of a number of tasks. Typically, a task will consist of material for the student to read and answer questions about. The major assignment is to write a paper or report. The tasks cover a wide range of topics, from history to sociology to art to poetry to science. The exam was intended to serve as a means of evaluating institutions rather than individual students. Although many were suspicious of the use to which it might be put, there was general agreement among teachers that it represented an innovative approach to assessment. ETS now owns the test and is marketing it to college and university systems. Dr. Angela Bodino, of the English department, and I have received a PEW grant in order to investigate the use of the GIS model as a way of evaluating students' critical thinking abilities and as a way of presenting material to enhance critical thinking.

While COEP was in effect, Raritan Valley Community College (RVCC) was actively involved in all of its components, with particular emphasis on the general education and major program evaluations. I was a member of the college-wide committee which reviewed program goals and objectives, and I helped develop such goals and objectives for the AS in Chemistry and the AS in General Science programs. Like most faculty members, I formulated and revised student outcome objectives for the courses that I taught. After the demise of the state-wide COEP program, RVCC has continued its own outcomes assessment at the general education, program and course level. This voluntary continuation is motivated partly by the perceived benefits of outcomes evaluation to the institution, to the faculty, and to the students, and partly by the uncertain but realistic prospect that the state would reimpose a similar mandate when and if funds became available.

Perhaps the most remarkable recent development has been the formation of the New Jersey County College Project on General Education by seventeen of the nineteen county colleges for the express purpose of developing goals, objectives, and assessment criteria for general education on a state-wide basis. I am a member of one of its four task forces, staffed by volunteer faculty and administrators from each of the colleges. Goals and objectives for general education have been written; we are currently engaged in developing assessment criteria and, if necessary, instruments for these objectives. The results will be distributed to the member institutions, undoubtedly debated and revised, until a final product is written. Each college will be free to adopt all or part of the general education assessment package. The democratic, participatory, grass-roots character of this effort is a continuation and expansion of the best spirit of COEP and, if successful, will be a model for further state-wide assessment effort.

Developing Goals, Objectives, and Assessment Instruments

There is an extensive body of literature dealing with outcomes assessment; this paper is not intended as a review or overview of the field. In my experience, one of the most lucid and practically oriented experts in the field is Professor Lion F. Gardiner of Rutgers University, who was a major consultant to COEP and is now assisting the

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County College project. Two of his most useful publications are a Handbook providing practical assistance to educators trying to develop assessment plans (Gardiner, 1991) and a resource paper listing (with brief commentary) a selection of publications covering a wide range of educational theory and practice in this area (Gardiner, 1992). Both are available from the New Jersey Department of Higher Education.

> Some of the flavor of Gardiner's approach can be sensed in an anonymous quote he uses: "If you don't know where you're going, you'll probably end up someplace else."

According to Gardiner, there are three crucial organizational components of a successful course or program: inputs (human and nonhuman resources), processes (courses, classroom techniques, lab experiments), and outcomes (student knowledge, skills, and achievements). In an operational sense, these three components are listed in their temporal order: one starts with the inputs, applies the processes, and concludes with the outcomes. In planning, however, the order is reversed: the first component to be determined should be the student outcome (what result do we want to obtain). Processes which can produce those results can then be devised, and the inputs necessary to support those processes are obtained.

This order seems at first glance to be a simple, even self-evident approach, but our collective teaching experience abounds with examples that are anything but consistent with it. In my own field of chemistry, for example, most of us haven't (until recently) spent much time thinking or talking about what we expect of our undergraduate students, particularly in the freshman and sophomore years. Our implicit long-term goal seems to have been to turn them all into chemists like us, this despite the fact that, even at research universities, over ninety per cent of the students in introductory chemistry courses are not chemistry majors, and even those who are more likely to be heading for medical or dental schools than chemistry graduate programs. The processes of the courses (content, methods, laboratory experiments, evaluation methods) are geared to this vague and implicit outcome, which for most of the students is both unobtainable and inappropriate.

There are, of course, student outcomes for an introductory chemistry course which are based on the acquisition of knowledge, or on the development of skills which are well-formulated and appropriately evaluated in traditional course formats. However, there are some outcomes which, once they are chosen and committed to, require that we carefully examine our courses and make some profound revisions in the teaching processes. In the last part of the paper, I will summarize a few of the revisions that I and my colleagues have made in response to two objectives developed for the AS Chemistry program.

<u>Objective 1.</u> *The student will exhibit an understanding of the scientific method: observe, make inferences, classify and organize information, analyze and synthesize data, draw conclusions, and communicate those conclusions in writing.*

At first glance, this seems to be a straightforward, if ambitious, objective. In the usual course, however, the methods employed hardly promote, much less guarantee, the desired outcome. The Scientific Method (in capitals) is presented in a lecture, perhaps with illustrative examples, for the students to memorize. In the laboratory, students perform experiments presented in a cookbook format, with numerical results inserted into blanks on preprinted data sheets which are torn out and handed in. Although the student may become skilled at certain lab techniques (which fulfills an entirely different objective), he or she may not understand the methods of science in any meaningful way, nor, in the event that he or she does understand, has there been any opportunity to demonstrate or exhibit that understanding.

Perhaps the most promising innovation in the pursuit of understanding in the laboratory is the Discovery or Guided Inquiry approach to the teaching of introductory chemistry laboratories (Pavelich & Abrahams, 1979; Allen, et. al., 1986, Ricci & Ditzler, 1991). As developed by Ditzler and his colleagues at Holy Cross, the teaching of general chemistry is driven by the laboratories: topics are usually introduced first in the lab where the students are given a problem or concept to explore, develop (with guidance from the instructor) hypotheses, experiment with different methods, decide how to analyze and report their data, and synthesize the entire class results into a conclusion that leads to insight into the underlying theoretical principles. The challenge to chemists is to develop open-ended experiments which are within the capabilities of beginning chemistry students, feasible with the equipment and supplies available, and yet interesting and profound enough to stimulate productive thought.

One of the simplest and most intriguing of the experiments developed at Holy Cross is "Pennies," an experiment which I have used at the beginning of the chemistry sequence in conjunction with a unit on measurement. The lab revolves around the question: "What happens to a penny as it ages?" Before going into the lab, the class as a group develops hypotheses (e.g., it loses mass), supported by reasons (e.g., frictional wear), and develops an experimental protocol to test the hypotheses (e.g., weighing pennies sorted by their mint year). When data has been gathered, the class discusses methods of analyzing the data (plotting mass against mint year). In this case, the pennies show no clear trend in mass gain or loss from year to year, but there is an abrupt drop in mass in 1932. This generates a new set of hypotheses to explain this discontinuity, which in turn must be tested (e.g., the densities can be determined to check for a change in composition, which is indeed the case; most of the copper was removed from the penny in 1982). If time permits, more extensive investigations can be performed. The beauty of this experiment is in its deceptive simplicity and accessibility even for the beginning student. Its openendedness and potential for fairly sophisticated elaboration are hallmarks of a well-conceived discovery experiment.

A second example is one that I have devised for a different group, second semester students in Organic Chemistry. One of the early experiments in a unit called Organic Qualitative Analysis (in which the students identify unknown compounds) is one in which the solubility characteristics of classes of compounds is explored. Traditionally, the students are presented with the classification scheme in a lecture with some theory and reaction equations to support it. They are then sent into the lab to verify the solubility patterns for known compounds and to classify an unknown compound by determining its solubility. In restructuring this experiment as a discovery lab, I have followed the lead of my colleague Roger Johnson, a plant biologist, who devised a similar restructuring for an experiment in the classification of twigs and branches based on a number of physical criteria.

In my variation, the class is given a set of known compounds (typically about ten distinct functional group classes) and a set of solvents (five or six aqueous and nonaqueous solvent mixtures). The class as a group develops hypotheses, trying to predict, based on their chemical knowledge and experience, the solubility behavior of the various compounds. They discuss an experimental approach, collect data in the lab, and analyze the results. With some guidance from the teacher, if all goes well, the class produces a classification scheme essentially identical to the one in the textbooks, but as a product of its own investigations.

<u>Objective 2</u>: *The student will be able to utilize information from the enormous and rapidly expanding chemical literature, both in libraries and in on-line interactive databases.*

This objective is realized through the completion of three categories of activities.

1) Literature search paper:
Students in the second semester of General Chemistry were given the following assignment:

> Write a paper describing the work of a prominent chemist of the last two centuries. Students will work in groups of two or three, choosing a chemist whose contributions are regarded as important. A reasonable starting point might be the list of Nobel Prize winners in chemistry, or the chemists whose work is described at various places in your textbook. Once I have approved your group and choice of a subject, you will find the necessary sources, put together a rough draft (which I will be glad to look at, if you wish), and then write the paper for submission. Each group will submit one paper; each member of the group will get the same grade for the assignment. Describe the major themes of the chemist's scientific work. If possible, discover how he or she regarded his or her place in the profession. Was there anything unusual in the way that the subject became a chemist, approached the field, or conducted his or her career? Describe the impact of the chemist's work on the science of chemistry and the chemists who followed. You must cite at least three sources, only one of which can be an encyclopedia article (no textbooks allowed). If possible, at least one source must be written by the subject of the paper. When the assignment was first announced, many of the students reacted with some dismay (a paper in a science

class?). Most of them expressed positive feelings about the assignment and their papers by the end of the semester, ranging from grudging acceptance to great enthusiasm. One experience particularly stands out: two female students chose to write about Dorothy Crowfoot Hodgkin, a pioneer in the development of X-ray crystallography who won the Nobel Prize for Chemistry in 1964. Their investigation of her career gave them a vivid lesson in both the opportunities and the obstacles facing women in science.

2) Individual experiments:

As the final laboratory experiment in Organic Chemistry II, the students were asked to select a synthesis from the literature, to adapt it if necessary to the equipment, supplies, and scale of the available resources, to perform the experiment, and to write up their results. Problems chosen ranged from the simple to the complex; a few students were ambitious and creative enough to put together a multistep synthesis. In addition to gaining familiarity with the literature and the search procedure, most students were gratified by a sense of ownership not felt in doing a textbook experiment.

3) Comparative articles:

When buckminsterfullerenes ("buckyballs") were first discovered and characterized, they caught the imagination not only of chemists and other scientists, but of the general population as well. My colleague and fellow chemist Sheila Cancella was inspired to use these appealing molecules to stimulate discussion of the various modes of scientific reporting in the literature. She handed out three articles: one from a refereed scientific journal (Science), one from a trade magazine (Chemical and Engineering News), and one from the popular press (TIME), all describing the discovery and structural features of buckyballs. The class discussed the similarities and differences in the treatments of the basic facts. Many scientific developments of the last few years lend themselves to this treatment, e.g., cold fusion, AIDS research, the Hubble space telescope, global warming.

In conclusion, despite the doubts and fears that outcomes assessment can engender in the teaching faculty, a carefully crafted set of objectives can trigger important improvements in course content, process, and evaluation. The lesson learned from the New Jersey experience has been that ownership and control by faculty and by local institutions is a key element in a positive and successful program.

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